

## **INTRODUCTION**

A standardized approach to watershed planning is required to manage the City's efforts to implement its Stormwater Management Plan. Watershed Plans will be developed for all major watersheds and will serve as standardized documents to help guide the City as it refines its Capital Improvement Plan (CIP). Previous planning efforts have been conducted by various organizations and Greenville County is currently conducting basin-wide studies throughout the County. These studies will be used in the development of Watershed Plans where applicable or when appropriate, jointly with Greenville County. This section provides guidance for merging findings from previous stormwater study efforts in the City of Greenville with new data and evaluations done to develop effective and consistent Watershed Plans.

## **STATUS OF WATERSHED PLANNING IN THE CITY OF GREENVILLE**

Local, state, and federal agencies have conducted comprehensive stormwater planning efforts as a part of their watershed planning programs for the following watersheds within the City of Greenville:

- Brushy Creek
- Henderson Basin
- Laurel Creek / Haywood
- East Laurel Creek
- Lanneau / Pine Forest
- Hidden Lake
- Upper Richland Creek
- Rocky Creek

Where possible, previous planning information should be included and built upon in developing Watershed Plans to take advantage of earlier efforts.

## **PLANNING METHODOLOGY**

**Organization of Watershed Plans** Watershed Plans will serve as the supporting documentation to the City's Stormwater Management CIP. The watershed planning methodologies and standards described herein will be used to develop a Watershed Plan for each major watershed. The objective is to supply the City with information on existing conditions, stormwater problems, alternative improvements considered to address stormwater problems, and other relevant information necessary to prioritize projects on a citywide level.

**Data Collection and Review** The initial step in Watershed Plan development is the collection and review of existing data. Data that will be collected and reviewed include stormwater problem data, existing watershed studies and models, monitoring data, geographic information systems (GIS) data and other sources of useful watershed mapping.

**Use of Existing Data for Watershed Studies** The Watershed Plan report will include a summary of existing watershed data and information. As a part of Watershed Plan development, the City will collect and review watershed data from applicable state and federal agencies, available complaint records, and other relevant watershed stakeholders. Relevant stormwater data will be compiled within the Watershed Plan report.

**Stormwater Problem Data** The Watershed Plans will include a comprehensive summary of stormwater problem data. The watershed problem summary will also include recommendations on the use of stormwater problem data. Other “problem categories” may arise as a part of Watershed Plan development, but generally they will be categorized as flooding, water quality problems, illicit sources, streambank erosion, and stream maintenance problems and will provide descriptions of standard problem categories to be used as a part of the watershed problem summary table.

**Existing Watershed Studies** Several local, state, and federal agencies have completed watershed studies and modeling for watersheds within the City of Greenville and Greenville County. Studies and the models used to support them may contain data useful to the development of Watershed Plans. These studies and others will be identified and reviewed as a part of Watershed Plan development. Watershed modeling has been performed for many of the studies and those models may be useful for the development of the Watershed Plan or other watershed planning activities to be coordinated by watershed stakeholder groups. Many of the models include data that are not fully documented to allow for a complete evaluation of their applicability to the Watershed Plan development. As a part of developing each Watershed Plan, the City will review and discuss the usefulness of existing watershed models for supporting the definition of problem areas, the development and evaluation of improvement projects and possible floodplain mapping revisions. Key criteria to be considered in defining the scope of Watershed Plan modeling activities includes age of the study or data, regulatory acceptance, and data quality and consistency.

**Existing Monitoring Data** Rainfall, stream flow (and stage), and water quality data may be available for watersheds within the City of Greenville or Greenville County. Some of the data may be used to support Watershed Plan modeling evaluations.

**Geographic Information Systems Data** Several sources of GIS data exist and are available to support watershed planning activities that will occur as a part of Watershed Plan. One primary source of GIS data is the City of Greenville. GIS data from Greenville County will also be obtained and used as appropriate as a part of Watershed Plan development.

**Watershed Analysis and Floodplain Mapping** The City has developed the following goals for watershed analysis and floodplain mapping that will be applied to the development of Watershed Plans. It is understood that meeting some of these goals may not be possible as a part of the Watershed Plan. These goals will be considered and applied wherever the City deems applicable:

- Hydrologic and hydraulic analyses must be consistent with FEMA map revision requirements.
- Hydrology for watershed plans will be determined by a hydrologic model that, where necessary, considers online and offline storage, infiltration, interflow, depressional storage, overland flow, spatially varied rainfall distribution, evapotranspiration, and soil moisture. The output from the hydrologic model must be compatible with the hydraulic model.
- Hydrologic analyses may require cooperative plans for watersheds that cross the City's corporate boundaries.
- Hydraulic conditions for the major watershed plans will be determined by a model that can, at a minimum, analyze the effects of floodplain encroachment, online and offline storage, diversions, channel improvements, bridges, culverts, dams, weirs, and other impediments to flow. The input to the hydraulic model will be compatible with the output from the hydrologic model. Fully dynamic models will be considered when channel conditions are extremely flat (for example, slope is less than 5 feet per 1,000) and subject to backwater conditions that make it difficult to approximate storage accurately.

**Watershed Modeling** The object of a Watershed Plan is to support the development and documentation of a citywide CIP for improvement projects. Understanding stormwater problems and evaluating scenarios to correct them requires the use of models and other watershed analysis tools. The City will develop standards for the application selection, data development, and calibration of hydrologic and hydraulic models to provide consistency throughout the Watershed Plan development. Several steps are involved in applying models to the development of a Watershed Plan. First, a model of existing conditions is developed to support calibration and an understanding of existing problems. Historical information will be used in the calibration of the existing condition models utilizing gage information, flood complaints, recorded high water marks and any other available information to insure the model accurately reflects the watershed conditions. Second, a baseline conditions model is developed to reflect the conditions expected to be current when the City begins to implement the CIP. This may include modifications to the existing conditions model that reflects projects that are under way and near completion. Finally, the model is modified to evaluate the effectiveness of alternative improvement projects.

**Screening Considerations** Several hydrologic and hydraulic modeling applications in the public and private domain are accepted by FEMA to determine floodplain and floodway areas for the National Flood Insurance Program. For Watershed Plans, the City of Greenville will specify the most appropriate hydrologic and hydraulic modeling application based on specific watershed modeling requirements. Factors for consideration include model familiarity, user base, data integration viability, model licensure, and GIS interface capabilities. In some cases, it may be acceptable to use two or more separate hydrologic and hydraulic modeling applications within the same Watershed Plan.

**Hydrologic Model Data Development** Hydrologic model data developed as a part of a Watershed Plan will be consistent with minimum City of Greenville standards. City of

Greenville standards will be developed to be consistent with the stormwater management program needs and wherever possible with state and federal agency preferences.

**Floodplain Mapping** Hydrologic and hydraulic modeling performed as a part of a Watershed Plan must be consistent with FEMA standards. FEMA has published standards that will be followed: *Guidelines and Specifications for Flood Hazard Mapping Partners* published by FEMA and available at [http://www.fema.gov/fhm/gs\\_main.shtm](http://www.fema.gov/fhm/gs_main.shtm).

**Problem Area Identification** Stormwater problem areas will be identified through stakeholder involvement, such as public meetings, discussion with other agencies, and logs of complaints. They will also be identified and confirmed as a part of the Watershed Plan. The Watershed Plan reports will summarize relevant and known stormwater problem areas and also watershed analyses to confirm the magnitude of flooding problems.

**Flooding Problem Areas** Flooding problems are defined as flooding of residential, commercial, industrial buildings, or transportation facilities that are critical to the economy and emergency services. Hydrologic and hydraulic models will be the primary method for evaluating flooding problem areas. Hydrologic and hydraulic models will be used to define water surface elevations for the 2-, 5-, 10-, 25-, 50-, and 100-year recurrence interval design storms. These elevations will be compared with top of foundation and first floor elevations for properties within the floodplain to develop flood damage curves. The methodology for developing flood damage curves and data required to support them will be developed by the City and will be consistent with methods necessary for state or federal mitigation assistance documentation.

**Erosion Problem Areas** Erosion problems are defined as streambank erosion along waterways that could result in property damage, risk to human health and safety, or a major contribution to stream sediment loading. As part of a Watershed Plan, the City will require an evaluation of streambank conditions to generally identify areas where erosion appears to meet these criteria. Special attention will be paid to areas where the City or other stakeholders have received complaints about erosion problems that are threatening structures or posing a risk to human health and safety. The City will visit the erosion problem areas identified and document existing conditions to support the evaluation of alternatives. Site visits will include the collection of survey data that is necessary to prepare conceptual level plans and cost estimates for alternative improvement scenarios.

**Maintenance Problem Areas** Maintenance problems are defined as restrictions on drainage caused by accumulation of debris and failed or damaged infrastructure. They will be identified through field visits or through stakeholder identification. Watershed Plans will identify maintenance problem areas and provide recommendations on their resolution. Efforts to identify the agencies responsible for maintenance within the watershed will be undertaken in the Watershed Plans.

**Water Quality Problem Areas** Water quality problem areas that are identified by state or federal agencies will assist in determining where water quality standards are not met. Water

quality benefits provided by projects planned as a part of Watershed Plan will be shown in qualitative terms as a part of the documentation of improvement projects identified.

**Wetlands, Floodplains, and Riparian Environment at Risk** Wetland, floodplain, and riparian areas will be identified as a part of a Watershed Plan. Wetland areas are identified on National Wetland Inventory (NWI) mapping. GIS data for NWI mapping are available on the Web (<http://www.fws.gov/nwi/>) for download and incorporation into Watershed Plans. Floodplain areas are delineated for many of the City of Greenville waterways and can also be summarized as a part of the Watershed Plan. Riparian zones generally are not delineated for City of Greenville waterways and will be defined as a part of a Watershed Plan. Wherever possible, a desktop evaluation of aerial photography or other available field data will be the method for identifying riparian zones. Riparian zones generally are defined as the interfaces between terrestrial and aquatic ecosystems.

**Estimates of Existing Damage** Estimating existing damages is the first step in defining the extent of problem areas. Damage estimates defined as a part of a Watershed Plan will focus on the economic damages caused by flooding and streambank erosion. Economic damages are estimated by summing damages from four categories:

- Property damage resulting from flooding (residential and commercial)
- Streambank erosion damage
- Transportation damage
- Recreation damage

The following subsections provide guidance on the economic valuation of damages and benefits that will be included as a part of Watershed Plan development.

**Property Damage** Property damage caused by flooding includes structural damage to buildings (residential, commercial, industrial, public) and loss of building contents (equipment, furnishings, raw materials, inventory). The extent of property damage depends on the severity of the flood. For riverine flooding typical of the City of Greenville, severity is dictated primarily by flooding levels and by high flow velocities and the duration of flooding. A floodplain inventory is necessary to understand the assets that are at risk. Hydrologic and hydraulic modeling is used to define water surface elevations for several storm events of varying probability of occurrence and to understand the impact on properties within the floodplain. Several public domain applications are available to support the development of average annual damages (AAD). Once the damages are calculated, a damage curve is developed by plotting the value of damages versus the exceedance probability. The AAD value, which can be determined by calculating the area under the damage curve, is essentially the sum of all the damages weighted by their probability of occurrence. A more detailed description of the methodology for determining property damages including the development of damage curves and performing benefit cost analysis will be developed by the City and incorporated into the Technical Guidance Manual.

**Streambank Erosion Damage** Streambank erosion damage will be calculated in a manner similar to property damage calculations. Surveys performed by the City will determine where streambank erosion is likely to cause property damage. In such cases, the valuation of the structure and the contents of structures deemed to be at imminent risk will be included. Therefore, frequency determinations are unnecessary, and evaluations will focus on effectiveness for the full range of expected flows, particularly bank full-flow ranges. Only actual property damage to structures will be included in the damage calculation. Loss of land will not be considered.

**Alternative Development and Evaluation** Once problem areas are defined and damages quantified, then alternatives to reduce the damages associated with the problems will be developed and evaluated. Several alternatives will be developed and evaluated for each problem area. For flooding problem areas, alternatives will provide a varying level of protection. In other words, some alternatives will address lower recurrence interval storms such as the 25-year storm, and others will address higher recurrence interval storms such as the 100-year storm. Once alternatives are developed, they will be evaluated based on their benefit-to-cost (BC) ratio or net benefit. While the intent is to provide protection to the 100-year storm, it may be economically beneficial to provide protection only to the 25-year event but cost prohibitive to provide protection to the 100-year event.

Generally, the City will recommend the alternative that provides the highest BC ratio or net benefit for each problem area. The City will also decide to consider non-economic criteria in the selection of alternatives for each problem areas. Information about non-economic criteria will be summarized for each project so that it can be included as a consideration in the citywide prioritization of stormwater improvement projects.

**Implementation Plan** Each Watershed Plan will include an implementation plan that identifies issues critical to implementation of watershed recommendations. The recommendations will include stormwater improvement projects to address watershed problems, maintenance needs and responsibilities, data management needs and responsibilities, special coordination requirements identified as a part of the Watershed Plan development, scheduled updates to Watershed Plans, and any other issues identified as critical to the City of Greenville.